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METEOROLOGICAL DATA LOGGER FOR USE IN STUDY OF AGRICULTURAL SPRAY DEPOSITION

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Acknowledgments

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The author also wishes to express appreciation to the Chrono-Log Corporation for permission to publish its wiring diagram shown in figure 8; and to Non-Linear Systems, Inc., for permission to publish its drawings shown in figures 3, 7, and 9.

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METEOROLOGICAL DATA LOGGER FOR USE IN STUDY OF AGRICULTURAL SPRAY DEPOSITION

By B. C. Haynes, Jr. [1]

HISTORY

Logging of meteorological data, with punched output for computer analysis, was initiated at the University of Georgia, Athens, Ga., in 1961. The first logger developed was of the analog to digital type, and it was utilized in the construction of a fixed agricultural meteorological station.

In 1963 a second analog to digital type logger was constructed for general laboratory instrumentation. This second piece of equipment is semiportable.

Both of the above data loggers utilized multipoint, recording millivoltmeters at the input end, and card punch output. Details concerning these loggers were reported by the Georgia Agricultural Experiment Stations. [2]

Both of these two data loggers have certain disadvantages. The punched card output is considered undesirable for unattended logging equipment, but lack of punched tape computer input, at this station, dictated its use. Arrangement of input signal conditioning sections in both pieces of equipment is awkward.

PROBLEM

The equipment described in this publication was developed in 1964 to instrument a research study located near Mayaguez, Puerto Rico. The study is concerned with deposition patterns of spray released slightly above the treetop level of a dense forest. To properly interpret these deposit patterns, measurement of various climatic parameters at several levels in the arboreal cover--wind velocity, wind direction, and dry bulb and dew point at four levels--was desired. Cumulative 24-hour precipitation occurring at exposed ground level was also desired.

SUGGESTED SOLUTION

The solution suggested involved application of a 20-point data logger. Three of the inputs involved time, instrument check, and power supply check. The other 17 points on the logger were used to record information from the following transducers: 4 anemometers, 4 wind direction vanes, 4 resistance bulbs, 4 Dewcels, and 1 tilting bucket rain gage.

Due to the isolated location of the project, it was essential that all equipment be as reliable as possible. It was also anticipated that analysis and correlation of data would be handled by a computer. For these reasons, a punched tape output was suggested.

Because the computer to be used for tape analysis was not located near the project, there was a need for an alternate method of tabulating data punched on the tape. This need was satisfied by utilizing a standard six-level Flexowriter code matrix for tape punching. This coding allowed running the tape through the tape reader of a Flexowriter that produced a printed output. The Flexowriter is a standard business machine and was available on a part-time basis.

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[2] B. C. Haynes Jr., Automatic Weather Station, Ga. Agr. Expt. Sta. Tech. Bul. N.S. 33, December 1963.

SEARCH FOR SUITABLE EQUIPMENT

At the time that this equipment was needed, a number of manufacturers were producing somewhat similar equipment. Most such similar equipment was designed originally for military or NASA application, and was designed primarily for high speed readout and one variety of input. When modified to suit the application, cost of such equipment was somewhat prohibitive. Recently, several firms started to market data logging systems that are more suitable to the application and less costly than that designed for military or space application. These firms also furnish input adapter circuits at reasonable cost for most kinds of transducers.

Since cost of the system was high and delivery time was limited, it was considered desirable to fabricate the complete system at Athens, Ga., using standard commercial components and subassemblies that were obtainable (fig. 1). To reduce engineering time and avoid mismatch of equipment, all possible standard commercial components were obtained from a single manufacturer.

A search of manufacturers' literature disclosed that one company[3] had available very suitable equipment, which they described as a scanner-tape punch. This one piece of equipment does the job of several standard

[3] Non-Linear Systems, Inc.

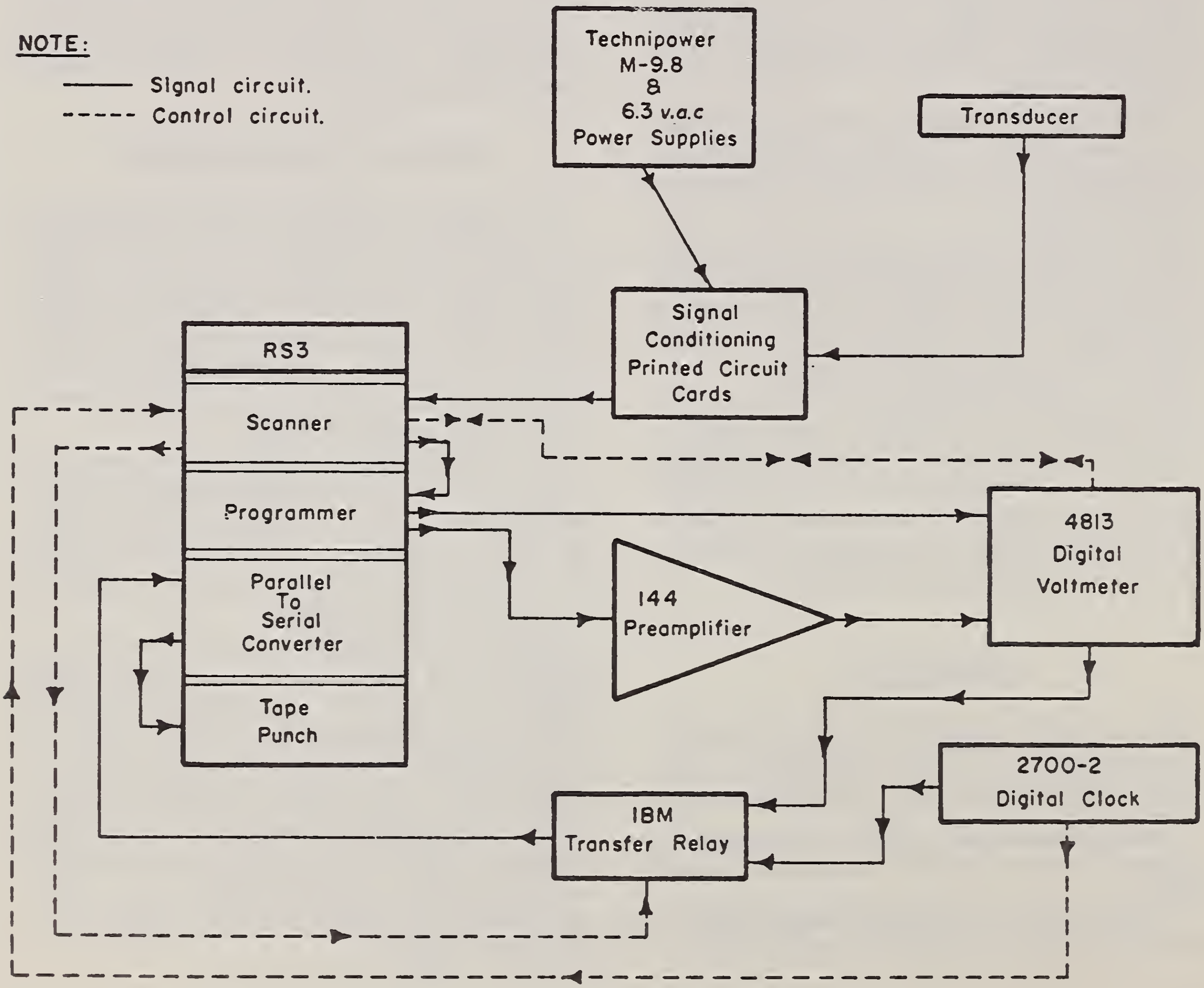

Figure 1.--Block diagram of data logger showing primary components.

commercial components. It functions as a 20-point input scanner. It acts as a parallel to serial converter. It incorporates a tape punch and punch pulse generating control circuit. It offers full matrix capability that permits setting up any 5-, 6-, 7-, or 8-bit punch code. It has input programming capability that allows routing one or more input signals through accessory devices and permits control of external input scanners, which handle up to 300 double-pole inputs, should it ever be desired to increase input capabilities of the data logger.

Non-Linear Systems, Inc., also manufactures preamplifier, digital voltmeters, and digital clock equipment that can be used with the scanner-tape punch. Further investigation revealed that the digital clock available from this company would not be suitable for this application. Their clock (a $1,200 item) has a digital voltage output that is not compatible with the scanner-tape punch, which accepts digital contact closure outputs. To make the two components compatible, a $600 buffer would be required.

However, a digital clock that is directly compatible with the scanner-tape punch was available from another company.[4] Because this clock cost only $600, a savings of $1,200 was effected.

GENERAL DESCRIPTION OF METEOROLOGICAL DATA LOGGER

Primary Components and Specifications

I. Non-Linear Systems RS 3 Scanner-Tape Punch.

This is a multiple-function component that combines the following capabilities:

A. A 20-point input scanner with illuminated channel identification display and digital output, function controls that can program the following capabilities:

1. Transducer signal directly to digital voltmeter (d.v.m.).
2. Transducer signal to digital voltmeter through accessory preamplifier.
3. Digital information from external device (clock) directly to serializer.
4. External scanner control (to 300 points) for increased capacity.

B. A parallel to serial converter to accept information in the form of parallel, digital, contact closures and to convert to serial, digital, contact closures.

C. A tape punch control capable of generating punch pulses and driving a tape transport and punch assembly under the command of a diode code matrix board that can be used to set up any 5-, 6-, 7-, or 8-channel code utilizing a maximum of 26 discreet numerals, characters, or symbols.

D. A tape transport and punch assembly, complete with takeup and capable of handling 1-inch-width paper or mylar tape.

II. Non-Linear Systems 144 Preamplifier. This is a high-gain, linear, direct current (d.c.), input signal conditioner with adjustable amplification set points of 3-5-10-30-50-100-300-500 and 1000 times gain. Common-mode rejection is 120 decibels (db) at 60 cycles per second (c.p.s.); 150 db at d.c. Gain stability $\pm$0.01 percent. Input resistance is 100 megohms.

III. Non-Linear Systems 4813 Digital Voltmeter.

This is a d.c. digital voltmeter with illuminated value display and digital contact closure output. It includes automatic polarity shift and is capable of reading from -9.999 volts to 0 volts to +9.999 volts. Input impedance is 10 megohms. Common-mode rejection exceeds 60 db at 60 c.p.s.

IV. Chrono-log 2700-2 Digital Clock.

This is a dual digital contact closure output clock with mechanical time display. Each of the two sections contains an output and a feedback circuit.

A. The 1/10-minute output circuit was used as an input to the scanner-tape punch to furnish data for tape punching. The 1/10-minute feedback circuit was utilized to drive the digital clock stepping switches and dials.

[4] Chrono-Log Corporation.

B. The 1-minute output circuit was modified and was used to provide time programming of the completed data-logger system. The 1-minute feedback circuit was utilized to provide a reset pulse for the rainfall transducer data-accumulator once each 24 hours.

V. Technipower[5] (M-9.8-0.750AY and NR-28.0-0.750) Dual Power Supply.

This is a standard, rack panel mounted, dual power supply to which an additional transformer has been added. Power supply sections are as follows:

A. A 9.8 v.d.c., 750 milliampere, highly regulated power supply to furnish power for operation of transducer d.c. bridge circuits and bias for calibration of thermocouple cold junction.

B. A 28.0 v.d.c., 750 milliampere, unregulated power supply for operation of accessory switch gear and thermocouple cold junction heating power.

C. A 6.3 v.a.c., 750 milliampere, unregulated power supply to furnish power for any a.c. transducer circuits that might be desired at a later date.

VI. Fenwal[6] Model 102, Catalog #53601-0 Proportioning Thermistor Controller.

This is essentially an anticipating type of thermostat that utilizes a thermistor as its sensing element. This thermostat is used to accurately maintain cold junction temperature. The amplifier of this control operates from a 115 v.a.c. line. Power is furnished to the cold junction heater, from the 28 v.d.c. unregulated power supply, through this control. The combination of cold junction temperature control and thermocouple circuit bias permits thermocouple range adjustment.

VII. American Pamcor Taper Pin Input Patchboard Assembly.

This patchboard was assembled from standard American Pamcor[7] (AMP) components as follows:

A. Taper Strip No. 595001,-20 cavity (10 each).

B. Taper Strip Cover No. 395002 for 20-cavity Taper Strip (1 each).

C. Taper Pin Connectors No, 42172-2, Beryllium Copper, Silver Plated, Single Formed (120 each).

D. Taper Pin Connectors No. 42173-2, Beryllium Copper, Silver Plated, Dual Formed (40 each).

Transducer input connections are made with AMP "53" Series Taper Pins No. 41648 for 22- to 24-gage wire and No. 41651 for 18- to 20-gage wire. All other (permanent) connections to the input patchboard are soft-soldered.

VIII. Input Signal Conditioning Section.

This section provided printed circuit receptacles and card guides for insertion of transducer bridge circuits and thermocouple cold junction (CJ) equipment (heater, thermistor, thermocouple CJ and thermocouple circuit bias adjustment potentiometer). The section was made up with the following standard parts:

A. Amphenol[8] Type 143-010-01 Printed Circuit Connector (20 each) with Type 143-953 Polarization Key (20 each).

B. Varipak[9] Printed Circuit Guide Strips Type 53-9011-3011 (6 each).

IX. Dewcel Power and Ballast Section.

Foxboro[10] manufactures these power supplies for multiples of 1 and 6 Dewcels. The minimum cost to handle 4 Dewcels was $150. This cost was reduced to $25 or less by utilizing other standard components as follows:

A. Signal Transformer Company Type 24-12, 24-volt, 12-ampere, power transformer (1 each).

B. 50-watt, 30-volt, incandescant light bulb (4 each).

X. Variable Resistance Counter Circuit With Electrical Reset.

This is a variable resistance output, electromechanical pulse counter capable of counting up to 600 discreet electrical pulses. Reset was accomplished each 24 hours with an electrical pulse furnished through the digital clock. Counting

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[5] Technipower, Inc.
[6] Fenwal, Inc.
[7] American Pamcor, Inc.
[8] Amphenol Corporation.
[9] Elco Corporation.
[10] Foxboro Company.

pulses were furnished by the rainfall transducer.

XI. Clock-Voltmeter Transfer and Format Shift Section.

Equipment in this section consisted of relays and diodes.

A. The primary relays and their use were as follows:

1. C. P. Clare Type 200 Cam Switch, single cam with 1-"ON" 4-"OFF" sequence, 30 contact cycles per rotation. Cam pile-up 2 form "C", Code 4. Interrupter 1 form "C", Code 4. Coil voltage 110 v.d.c. This relay was used to procure desired format change in the 11th character of every 5th word. The format change was from punch "SPACE" to punch "CARRIAGE RETURN."
2. International Business Machines Type 196196H Wire Contact Relay, coil #U198882H, 28 v.d.c., 6 form "C" contacts. This relay was used to procure format shift in the 3d, 4th, 5th, 7th, 8th, and 9th character of every 20th word. The relay also served to effect transfer of clock output for digital voltmeter output.
3. A Sigma Type[11] 23JOXC 2500 GD-SIL Relay and . . . A Potter & Brumfield Type MB3D Relay plus . . . Necessary Blocking Diodes. These components were used to procure desired action of the relay listed in preceding paragraph 1.

XII. Par-Metal[12] DeLuxe Console Assembly. This is a rack pedestal frame equipped with casters, exterior side panels, and pedestal frame door. A vertical desk panel cabinet is mounted on the top rear of the pedestal frame, and a formica-bonded table top covers the top front of the pedestal frame. All primary components of the logger were mounted within this console assembly (fig. 2).

[11] Sigma Instruments, Inc.
[12] Par-Metal Products Corporation.

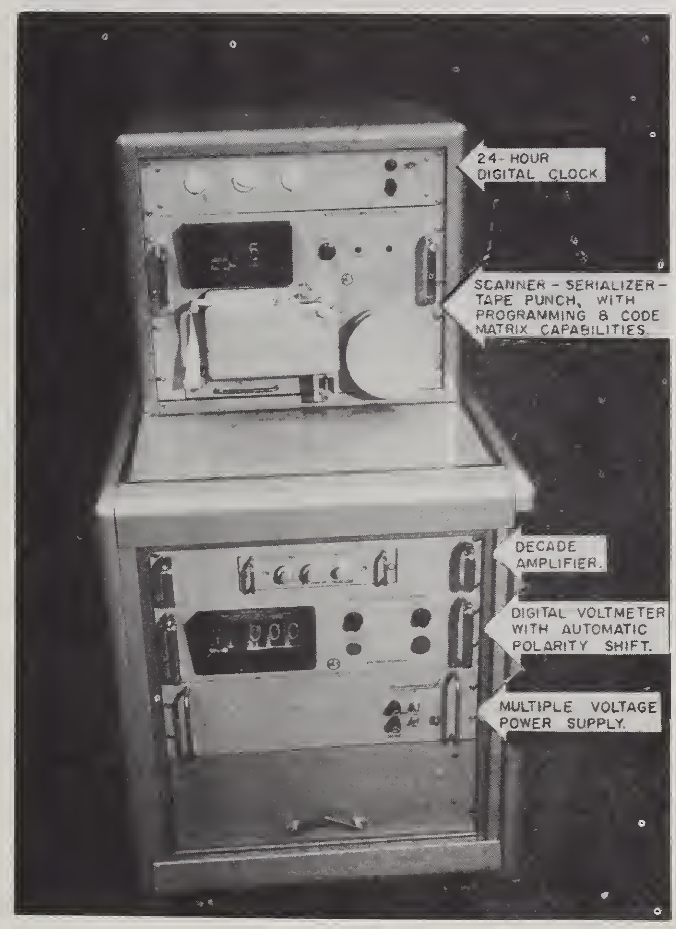


Figure 2.--Front view of logger.

Word Capacity

Eleven characters form each word.

Format

#1 YYHWW.WWWTS
#2 YYMPX.XXXTS
#3 YYMPX.XXXTC

YY = scanner position 00-19
H = symbol indicating hour
WW.WWW = digital clock output with fixed decimal after hour
T = symbol command "TABULATE"
S = symbol command "SPACE"
M = symbol indicating millivolts
P = + or - polarity
X.XXX = d.v.m. output with fixed decimal after whole millivolt
C = symbol command "CARRIAGE RETURN"

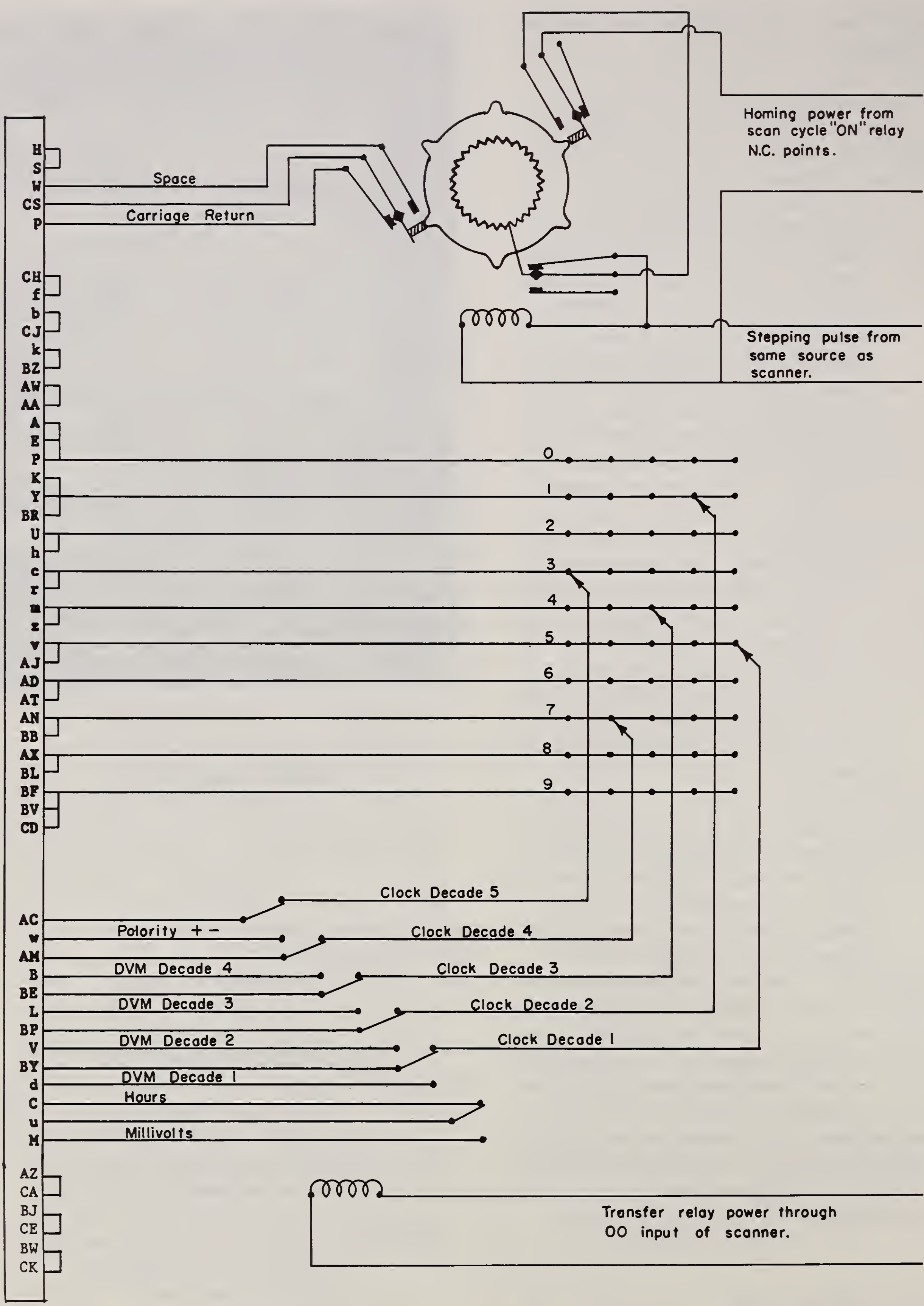


Figure 3.--Program plug wiring diagram showing interconnection of d.v.m. and scanner plus transfer relay connections for exchange of clock and d.v.m. information.

Format shift was accomplished by two transfer relays, as shown on the program connector wiring diagram (fig. 3) and listed under "Program Connector Wiring."

The transfer of clock for d.v.m. is accomplished by an IBM six-pole double-throw (6 p.d.t.) wire contact relay. The transfer of symbols for hours and millivolts is handled by one form "C" contact on this relay.

Format shift for substitution of symbol commands "SPACE" and "CARRIAGE RETURN" is handled by a Clare Type 200 cam stepping switch. Additional cam "C" contact and interrupter "C" contact is utilized to "HOME" the relay and assure synchronization with the input scanner at the start of each 20-point readout cycle (fig. 4). Point 00 always reads out clock information, and points 01 thru 19 are utilized for data input readout.

The format is arranged so that when played back on a standard Friden Flexowriter it tabulates as shown in figure 5.

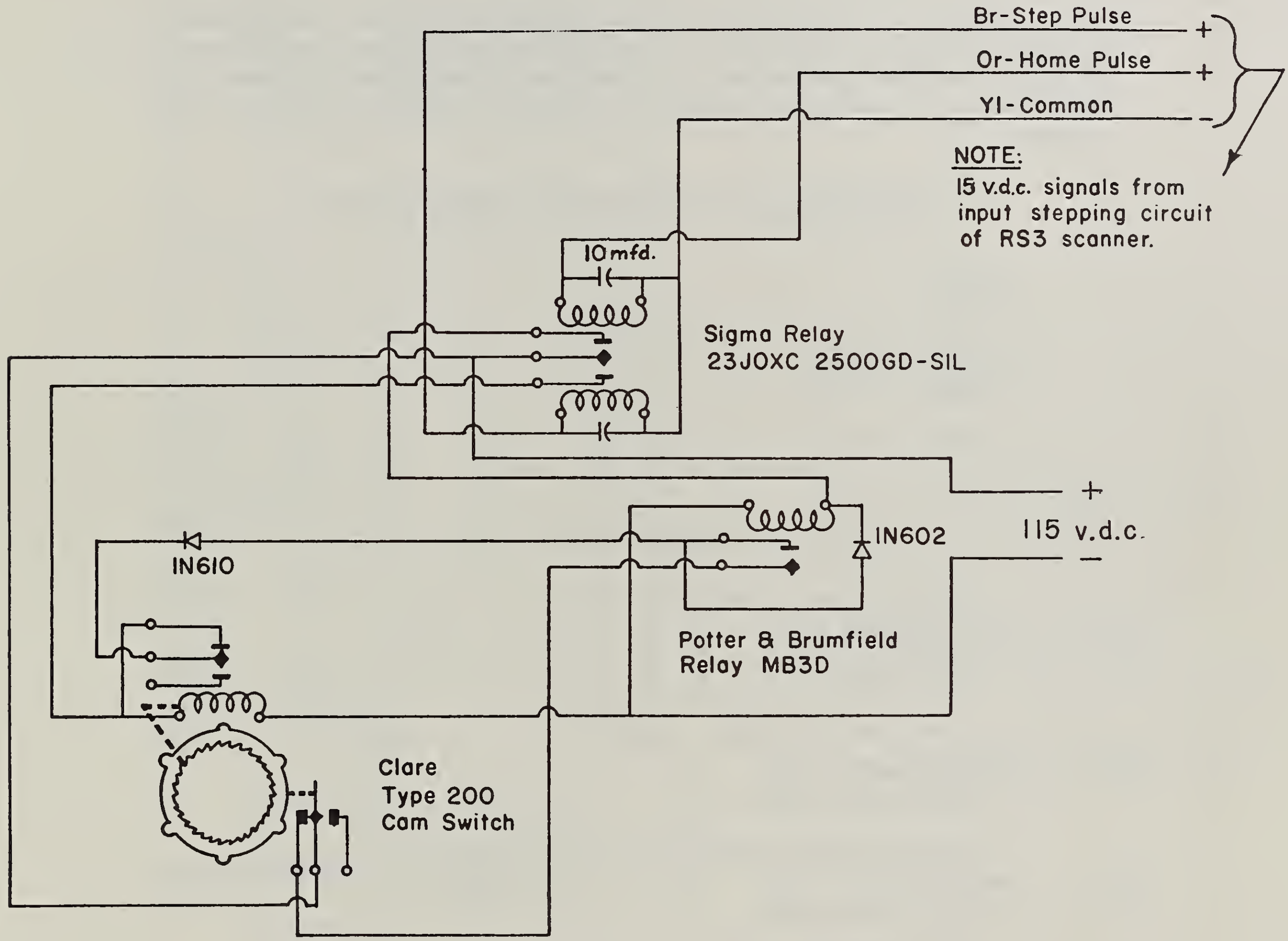


Figure 4.--Cam stepping switch and associated circuitry utilize to "pulse" and "home" stepping switch.

00h07.210	01m0.789	02m0.369		
03m0.039	04m0.329	05m0.109	06m0.789	07m0.379
08m0.039	09m0.000	10m0.001	11m0.779	12m0.389
13m0.030	14m0.709	15m0.499	16m0.789	17m0.379
18m0.039	19m0.000			
00h07.260	01m0.779	02m0.369	03m0.019	04m0.329
05m0.109	06m0.789	07m0.379	08m0.029	09m0.000
10m-0.000	11m0.779	12m0.379	13m0.032	14m0.709
15m0.499	16m0.789	17m0.379	18m0.019	19m0.000
00h07.210	01m0.789	02m0.379	03m0.029	04m0.329
05m0.109	06m0.789	07m0.379	08m0.039	09m0.000
10m-0.000	11m0.779	12m0.379	13m0.021	14m0.709
15m0.499	16m0.789	17m0.379	18m0.007	19m0.000

Figure 5.--Three actual readouts from tape played back on a Friden Flexowriter are illustrated. It should be noted that the Clare transfer stepping relay was out of synchronization with the logger punchout during the first readout. At the completion of the first readout the Clare relay "homed", and subsequent punchouts produced normal readouts.

PROGRAM CONNECTOR WIRING

	Format											
	#1	Y	Y	H	W	W	.	W	W	W	T	S
	#2	Y	Y	M	P	X	.	X	X	X	T	S
	#3	Y	Y	M	P	X	.	X	X	X	T	C
Pulse	#	1	2	3	4	5	6	7	8	9	10	11
Pin	#	b -	k -	u	-AC	-AM	-AW	-BE	-BP	-BY	-CH	-CS

AM < B 4th decade d.v.m. / thru transfer relay / 4th decade clock

BE < L 3rd decade d.v.m. / thru transfer relay / 3rd decade clock

BP < V 2nd decade d.v.m. / thru transfer relay / 2nd decade clock

BY < d 1st decade d.v.m. / thru transfer relay / 1st decade clock

AC < w Polarity d.v.m. / thru transfer relay / 5th decade clock

u < C hours / thru transfer relay / M millivolts

d.v.m. - clock exchange

H -- S 11-character word

AW -- AA fixed decimal point

CS — P carriage return / thru cam switch / W space — insert space 1-2-3-4-6-7-8-9, etc. carriage return -5-10-etc.

CH -- f (SP4) tabulate

k -- BZ 1st decade scanner

b -- CJ 2nd decade scanner

A --	E & P	0	External digits and scanner position
K --	Y & BR	1	
U --	h	2	
c --	r	3	
m --	z	4	
v --	AJ	5	
AD --	AT	6	
AN --	BB	7	
AX --	BL	8	
BF --	BV & CD	9	

AZ-CA
BJ-CE
BW-CK — internal scanner utilized

Schematic wiring diagram of the program connector plug, as indicated by the previous table, is illustrated in figure 3.

TAPE CODING

A 1-inch-wide tape, with 6 channel flexowriter coding, is utilized. Character punch coding is as shown in figure 6.

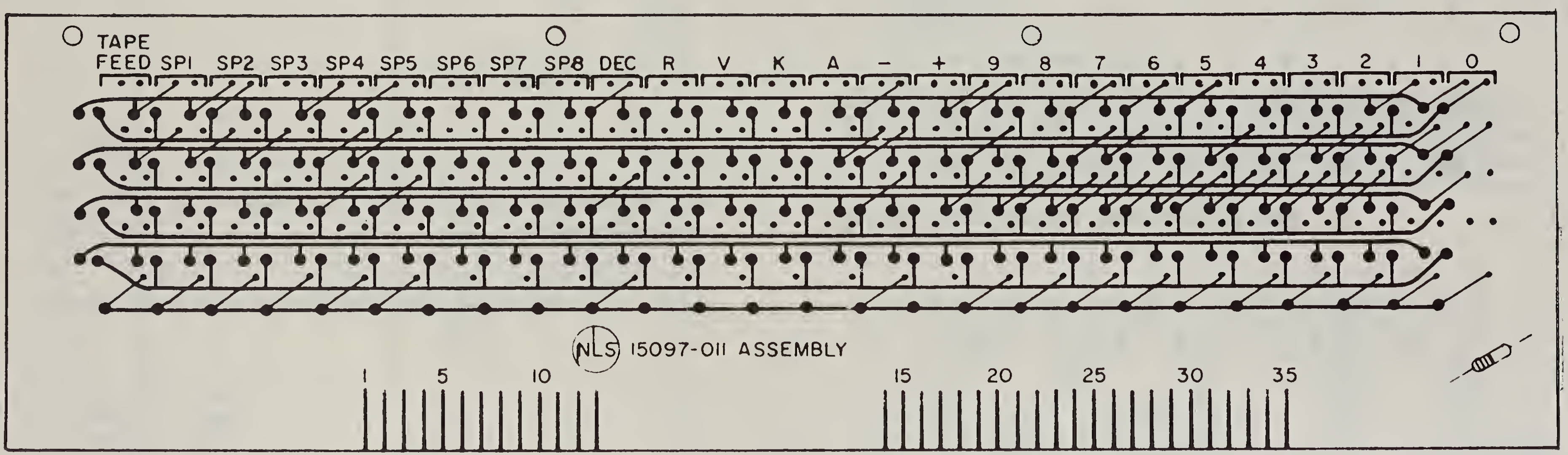
Code matrix board wiring required for the preceding code tabulation is as shown in figure 7.

CHARACTER				6	1	2		3	4	5
0					●	●	•	●	●	●
1						●	•			●
2				●	●	●	•	●		
3				●	●	●	•			
4				●	●		•	●		
5				●	●		•		●	
6				●	●		•	●	●	
7				●	●	●	•		●	
8				●	●		•			
9					●	●	•		●	●
• (Decimal)				●			•		●	
— (Minus)				●		●	•	●	●	
h (Hours)	*Special 1*						•	●		●
m (Millivolts)	*Special 2*						•	●	●	●
Space	*Special 3*						•	●		
Tabulate	*Special 4*			●		●	•			●
Carriage Return	*Special 5*			●			•	●		●
Tape Feed							•			
		8	7	6	5	4	9	3	2	1

FLEXOWRITER CODE (top column labels); MATRIX BOARD COLUMN NO. (bottom row)

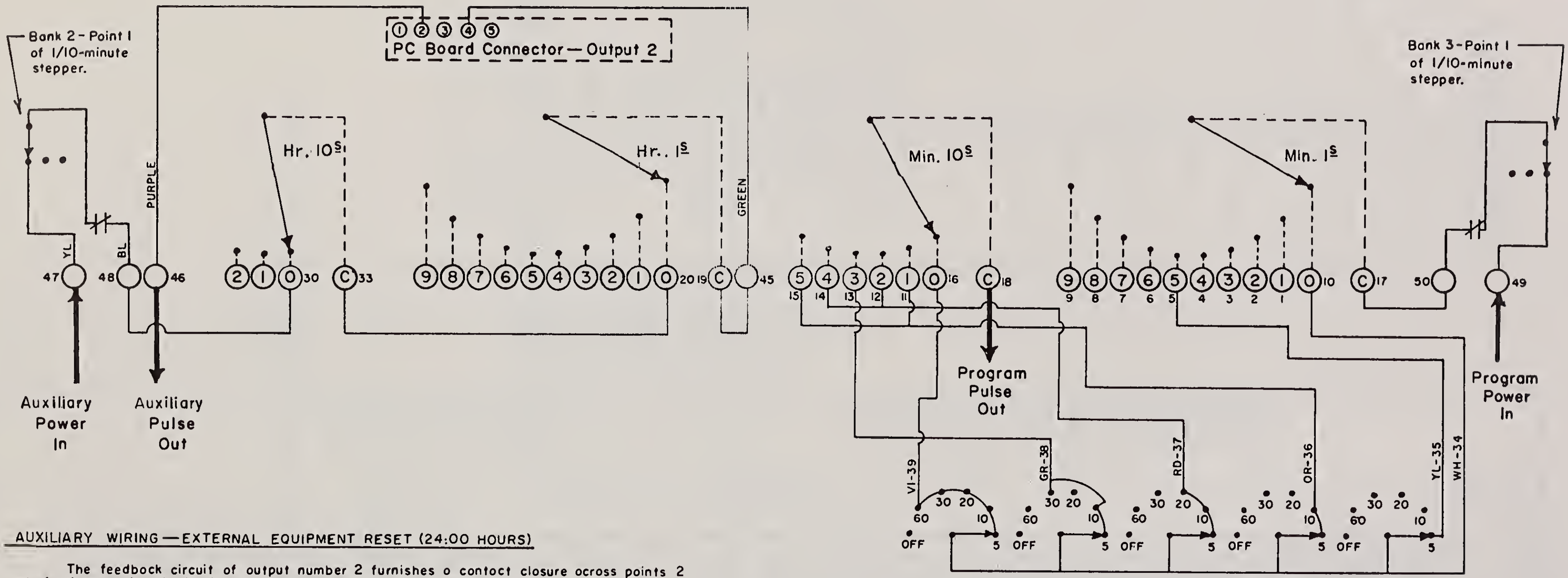
Guide Edge

Figure 6.--Six-bit (column) Flexowriter code originally used for logger tape-punch.



NOTE: Diagonal lines represent diode placement for desired code matrix.

Figure 7.--Diode insertion in tape-punch code matrix board to produce code shown in figure 6.



AUXILIARY WIRING — EXTERNAL EQUIPMENT RESET (24:00 HOURS)

The feedback circuit of output number 2 furnishes a contact closure across points 2 and 4 of the printed circuit board connector once each hour. By wiring this circuit through the hours 10^{s} and hours 1^{s} of output number 2 a discreet contact closure is obtained at 24:00 hours each day. This circuit is utilized to reset the rainfall counter mechanism to zero.

Unused Cannon connector pins 45 through 48 are used for internal wiring. The mating Cannon plug is jumpered to obtain connections shown above and listed below.

47 - - - - - Auxiliary power in.
48 - 30
33 - 20
19 - 45
46 - - - - - Auxiliary pulse out.

PROGRAM WIRING — DIGITAL CLOCK AND LOGGER SYSTEM

Wiring diagram above indicates method of wiring a 5 level, 6 position, rotary switch through the minutes 10^{s} and minutes 1^{s} output number 2 of the digital clock. The data logger can be programmed to read out each 5, 10, 20, 30, or 60 minutes by appropriate positioning of the rotary switch.

Large numbers within the circles represent minutes 10^{s} and minutes 1^{s} positions of the clock. Small numbers beside the circles represent the pin numbers of the Cannon connector furnished for clock output. The 6 leads from the rotary switch are connected internally to unused pins 34 through 39 of the Cannon connector. The mating Cannon plug is then jumpered to obtain the desired connections shown above and listed below.

49 - - - - - - Program power in..
50 - 17
10 - 34 (white)
5 - 35 (yellow)
11 - 15 - 36 (orange)
12 - 14 - 37 (red)
13 - 38 (green)
16 - 39 (violet)
18 - - - - - - Program pulse out.

Figure 8.--Clock modification showing addition of readout control switch and circuits and external device reset circuit.

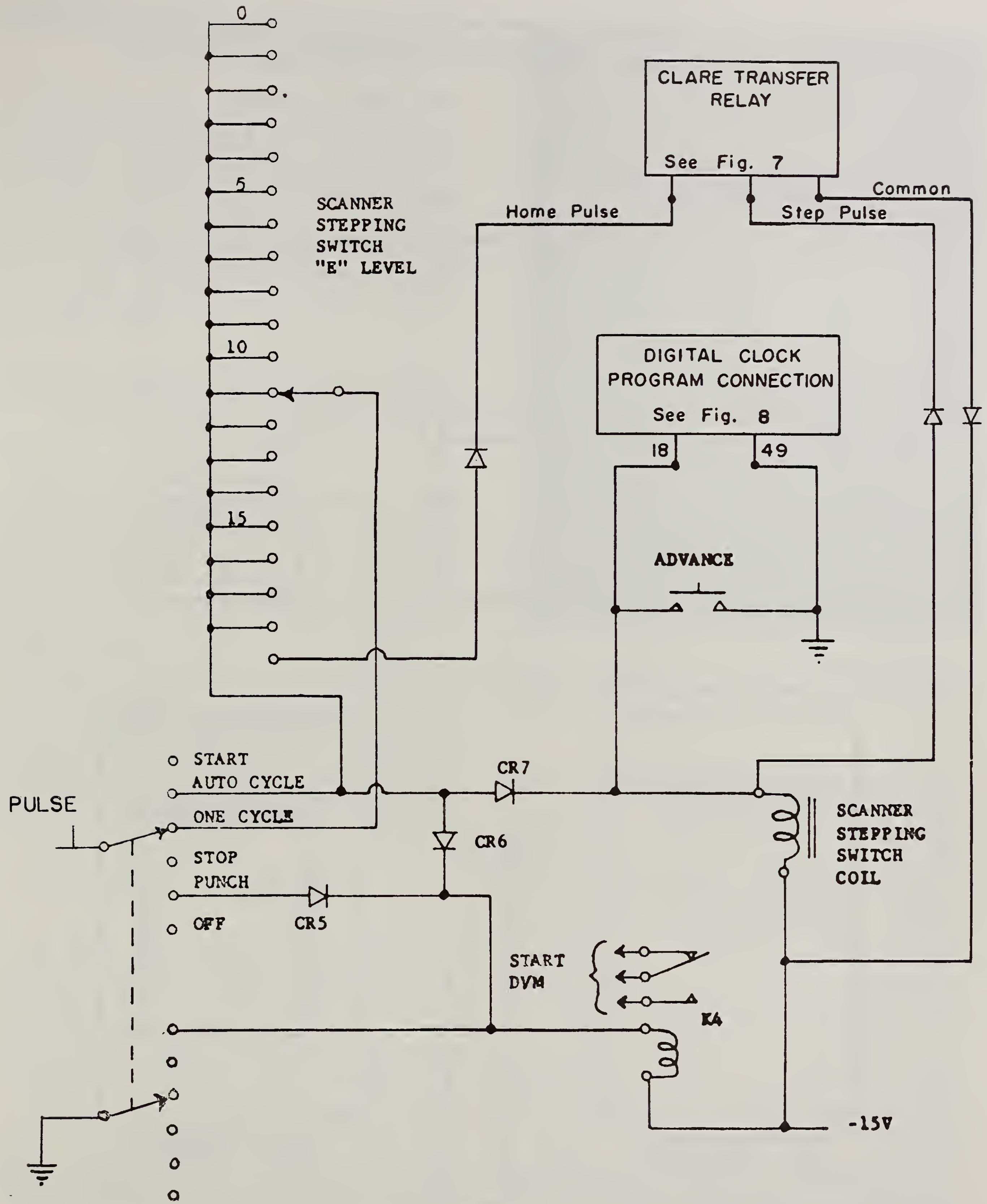


Figure 9.--Interconnection of digital clock and format shift relay circuit with scanner-tape punch.

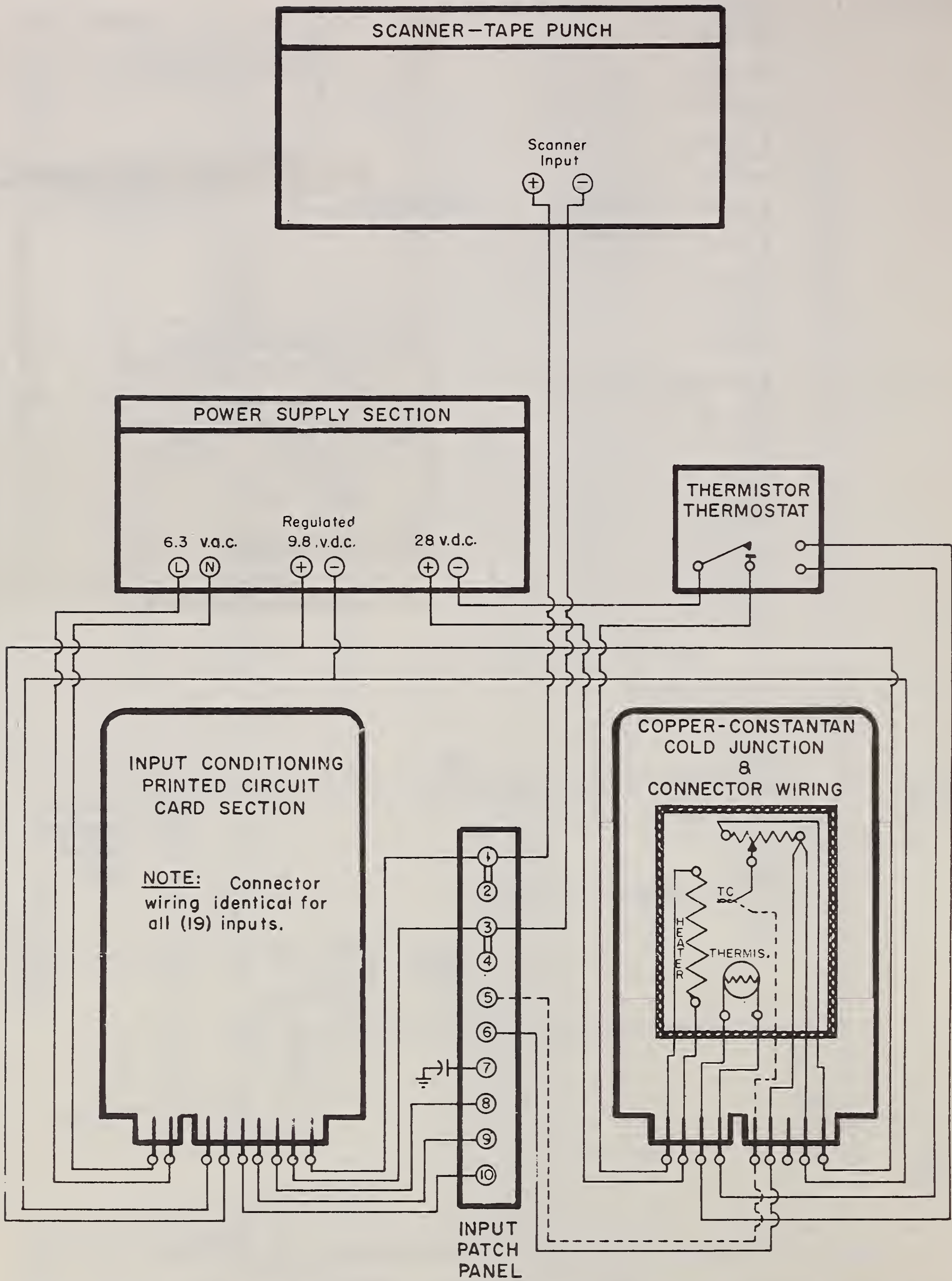


Figure 10.--Input wiring diagram showing relation of input jacks, printed circuit receptacles, power supplies, thermocouple reference and input scanner.

PROGRAM TIMING AND AUXILIARY EQUIPMENT RESET

The standard model Chronolog Digital Clock has been modified by the addition of a 5-pole, 5-section, 6-position rotary switch as shown in figure 8 to provide for logging intervals of 5, 10, 20, 30, or 60 minutes. Additional modification has been accomplished to provide an external equipment reset pulse at about 24:00 hours. This reset pulse is utilized to return the rainfall circuit to zero position at midnight each night.

INTERCONNECTION OF SCANNER-TAPE PUNCH, CLOCK, AND FORMAT SHIFT

Figure 9 shows the interconnecting wiring necessary to permit clock control of the logger readout cycle. This same figure shows the method of obtaining pulses to operate the Clare stepping relay and associated control circuitry in synchronization with the Scanner-Tape Punch.

The IBM transfer relay is energized by a circuit through the 00 input of the scanner. The arrangement is possible due to the lack of any signal on this input. The IBM relay remains energized to effect exchange of clock information for voltmeter information so long as the scanner remains in the 00 position.

INPUT PROVISIONS

All inputs are through an AMP taper-pin terminal board in the rear of the logger cabinet. Each point of input is handled by two or more jacks of a total of eight jacks. The input arrangement is similar to that shown in figure 10. Since each input set of taper jacks, (fig. 11), is wired to a printed circuit (PC) board receptacle, which also, has a.c. and d.c. power supply inputs, any input can be fitted to the logging system by the insertion of a simple PC board (fig. 12). Any thermocouple input (copper-constantan) can be handled without a PC board.

In initial design stages, it was contemplated that thermocouples would be utilized for all dry bulb temperature measurements. For this reason the preamplifier specified has a maximum gain of 1000 which permits the digital voltmeter to measure signals in the range between zero and ± 9.999 millivolts. This original design also incorporated built in cold junction for thermocouple circuits. Although the completed data logger incorporates the above capability of reading thermocouple outputs to the nearest microvolt, it was decided to utilize resistance thermometers for dry bulb temperature measurements.

Figure 11.--Rear access to logger showing input jacks, input conditioning section, Dewcel power section, etc.

Two factors influenced the decision to change from thermocouples to resistance thermometers. First, and foremost, was the desire to have all readouts in direct form. The use of thermocouples would have necessitated reference to standard conversion tables to determine temperature in degrees Fahrenheit. The second factor considered was the effect of strays and transients with the high-gain, low signal level arrangement. By utilizing resistance bulbs it is possible to use preamplification gain of 100, and thus reduce

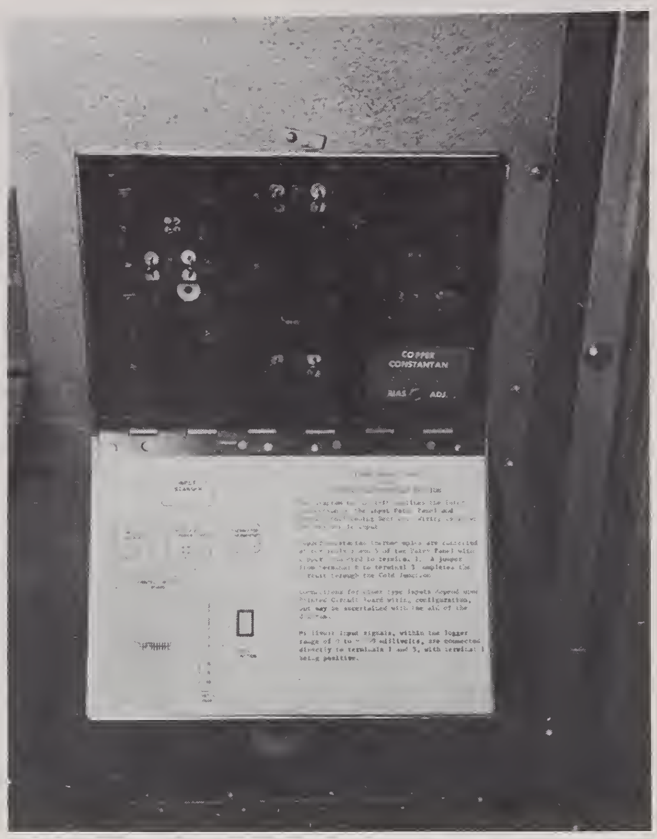


Figure 12.--Input conditioning section opened showing printed circuit cards in position. Note that all adjustment potentiometers are readily accessible at this location.

amplification of strays and transients by a factor of 10. This second factor was considered important since the data logger with its related circuits is powered by a gasoline-engine-driven alternator.

TRANSDUCER CIRCUITS

Each temperature and dewpoint transducer, with its related printed circuit (PC) board in the signal conditioning section, forms a d.c. bridge circuit. Fixed, precision resistors are used in the bridge circuits; hence, there is no adjustment for set point (e.g., the set point is permanently fixed). Trimpot variable resistors are utilized to form an input voltage tap for each bridge circuit. The two trimpots used on each printed circuit board provide for coarse and fine adjustment of the transducer circuit span (fig. 13).

Each wind direction and precipitation transducer, with its related printed circuit board, forms a d.c. bridge circuit. An adjustable resistance in one arm of each of these bridges permits zero setting of the bridge output. Trimpot variable resistors form an input voltage tap for each bridge circuit. See figures 14 and 15.

Each wind velocity transducer feeds an a.c. voltage to its related printed circuit board. A diode bridge on the PC board rectifies the output that is then filtered. Trimpot variable resistors are utilized to form an output voltage tap to calibrate transducer circuit span (fig. 16).

One printed circuit board in the signal conditioning section is utilized to short out the input to the scanner. This provides a punched channel of information concerning the proper operation of the preamplifier and digital voltmeter units.

A second printed circuit board in the signal conditioning section is utilized to feed a portion of the bridge circuits supply voltage to the scanner input. This provides a punched channel of information concerning the proper operation of the preamplifier, digital voltmeter and bridge power supply units (fig. 17).

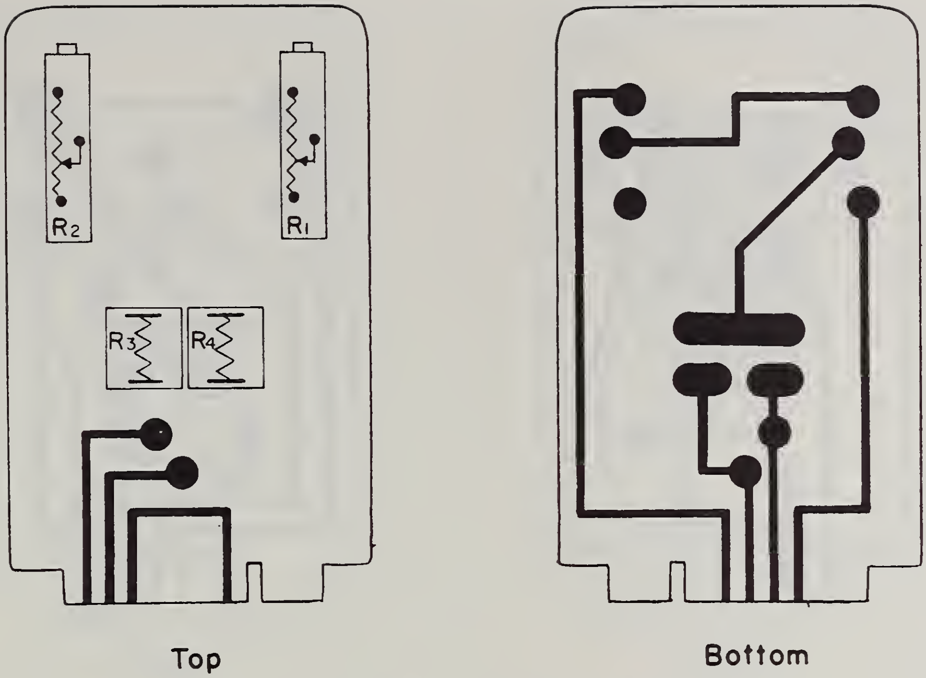
All of the circuits are essentially linear; hence, readouts can be adjusted to absolute values.

ELECTROMECHANICAL COUNTER

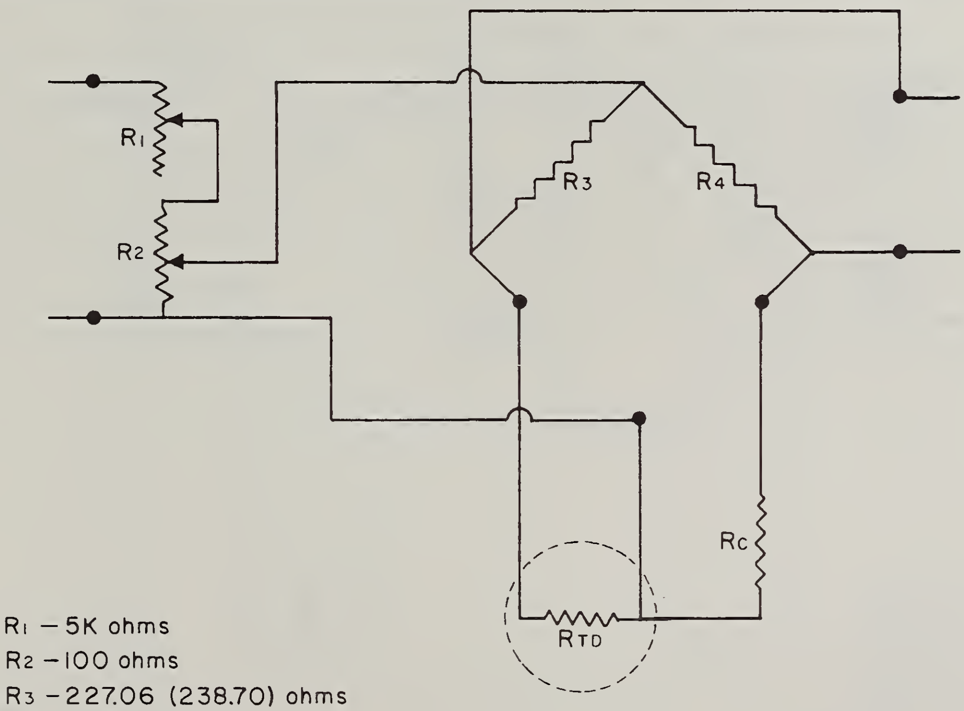
Description

The counter described is intended primarily for use as a discrete pulse counter. It has particular application to automatic recording and logging equipment for adaptation of transducer signals. Essentially it counts contact closures and accumulates the count in the form of a variable, increasing (or decreasing) resistance. Electrical zero reset is provided by the mechanism.

When its potentiometer is employed as a voltage tapping device the counter can be utilized, in conjunction with a tilting bucket gage, to display 24-hour cumulative precipitation on a voltmeter.



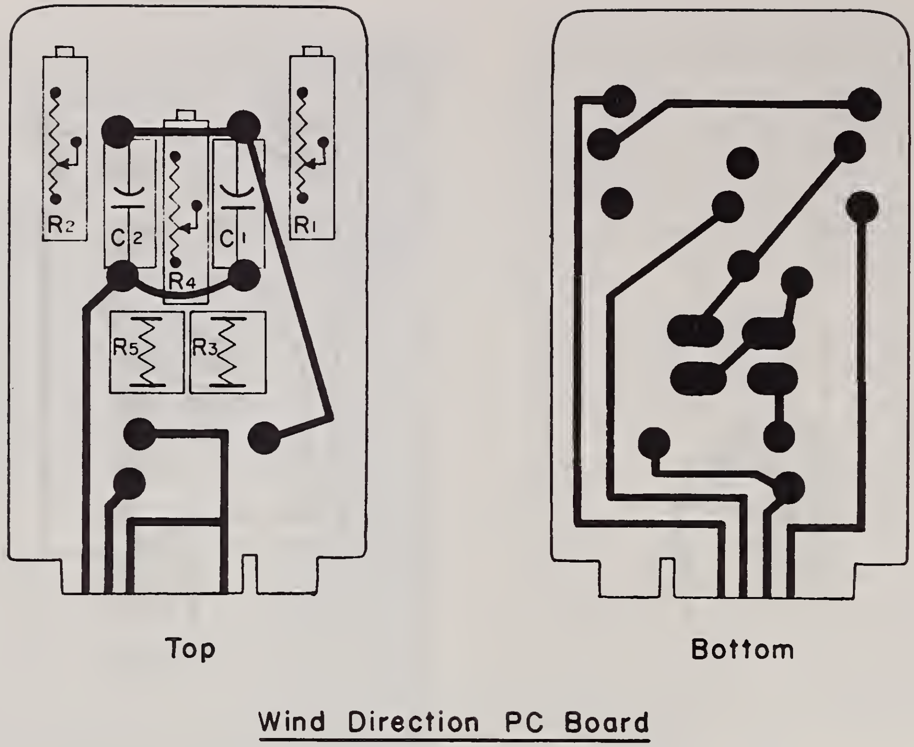
Dry Bulb (Dew Point) PC Board



R_1 – 5K ohms
R_2 – 100 ohms
R_3 – 227.06 (238.70) ohms
R_4 – 217.53 ohms
R_C – 217.53 ohms furnished in transducer assembly
R_{TD} – Foxboro DB-IR-26W Dynatherm
(2711AG Dewcel)

Dry Bulb (Dew Point) Circuit

Figure 13.--Dry bulb and Dewcel printed circuit cards and wiring diagrams.



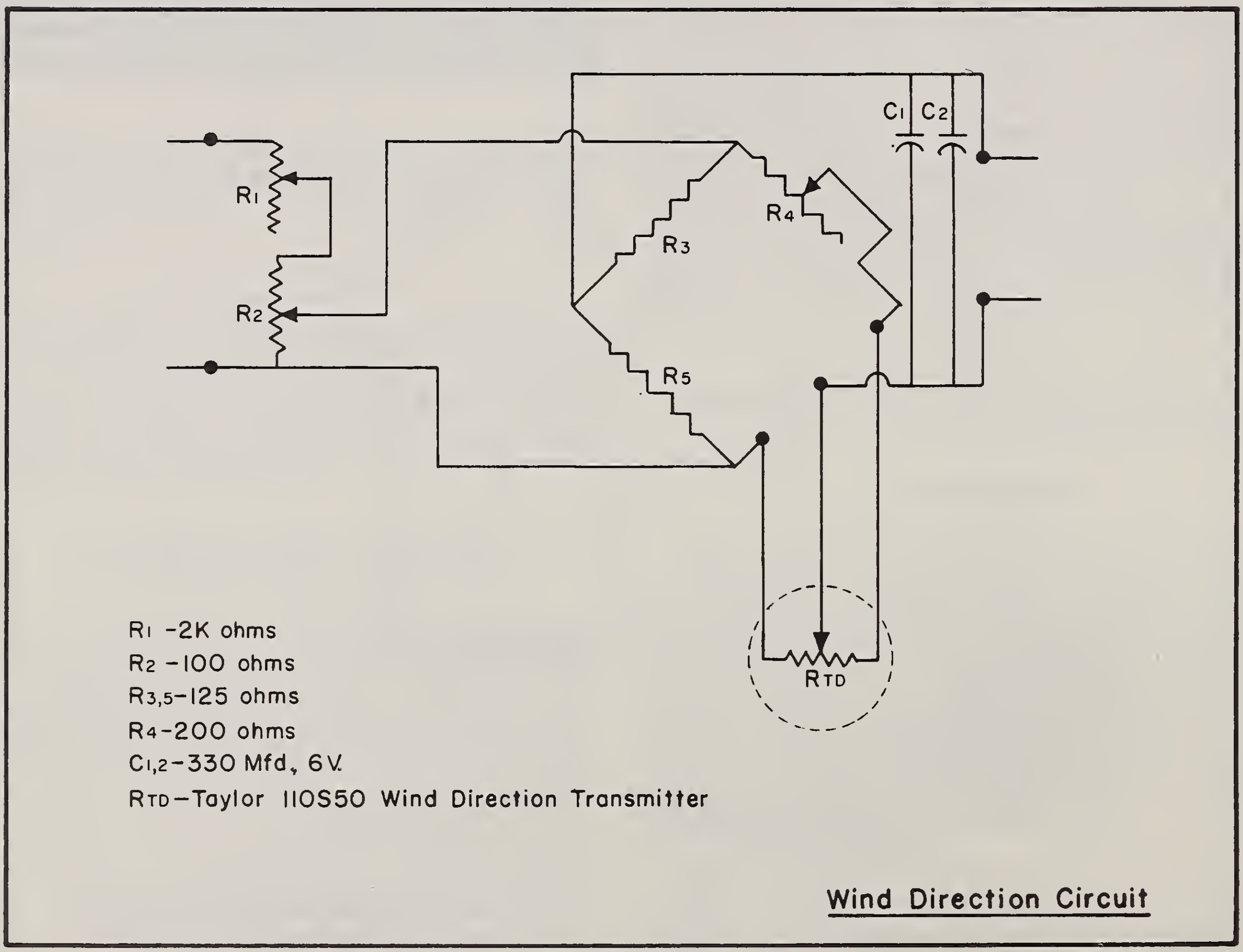


Figure 14.--Wind direction printed circuit card and wiring diagram.

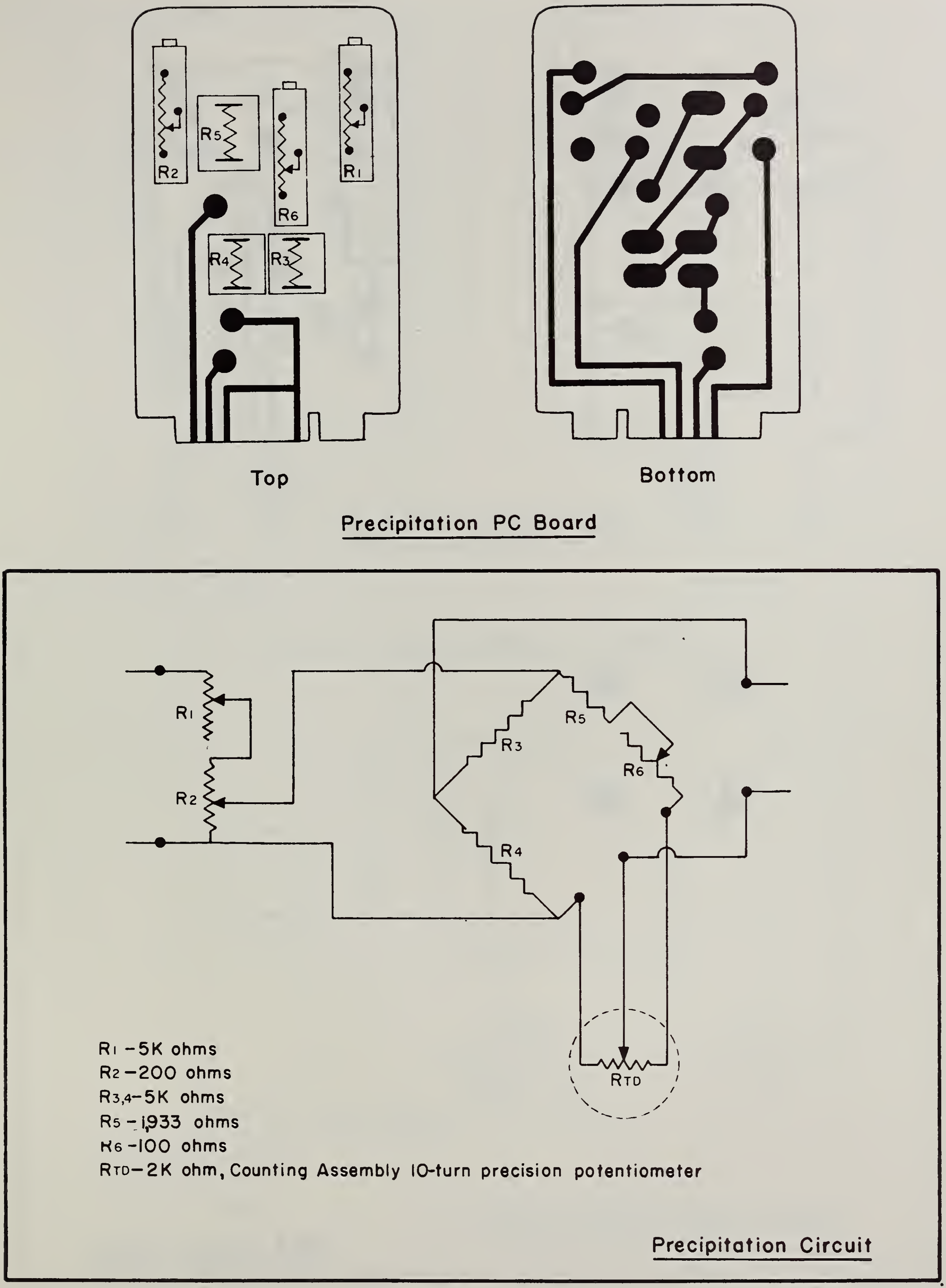
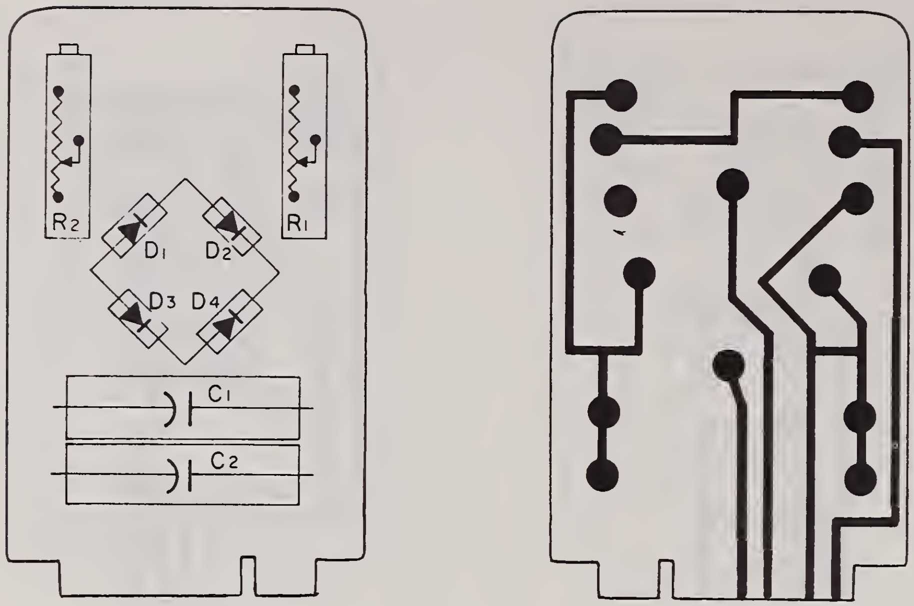


Figure 15.--Precipitation printed circuit card and wiring diagram.



Top

Bottom

Wind Velocity PC Board

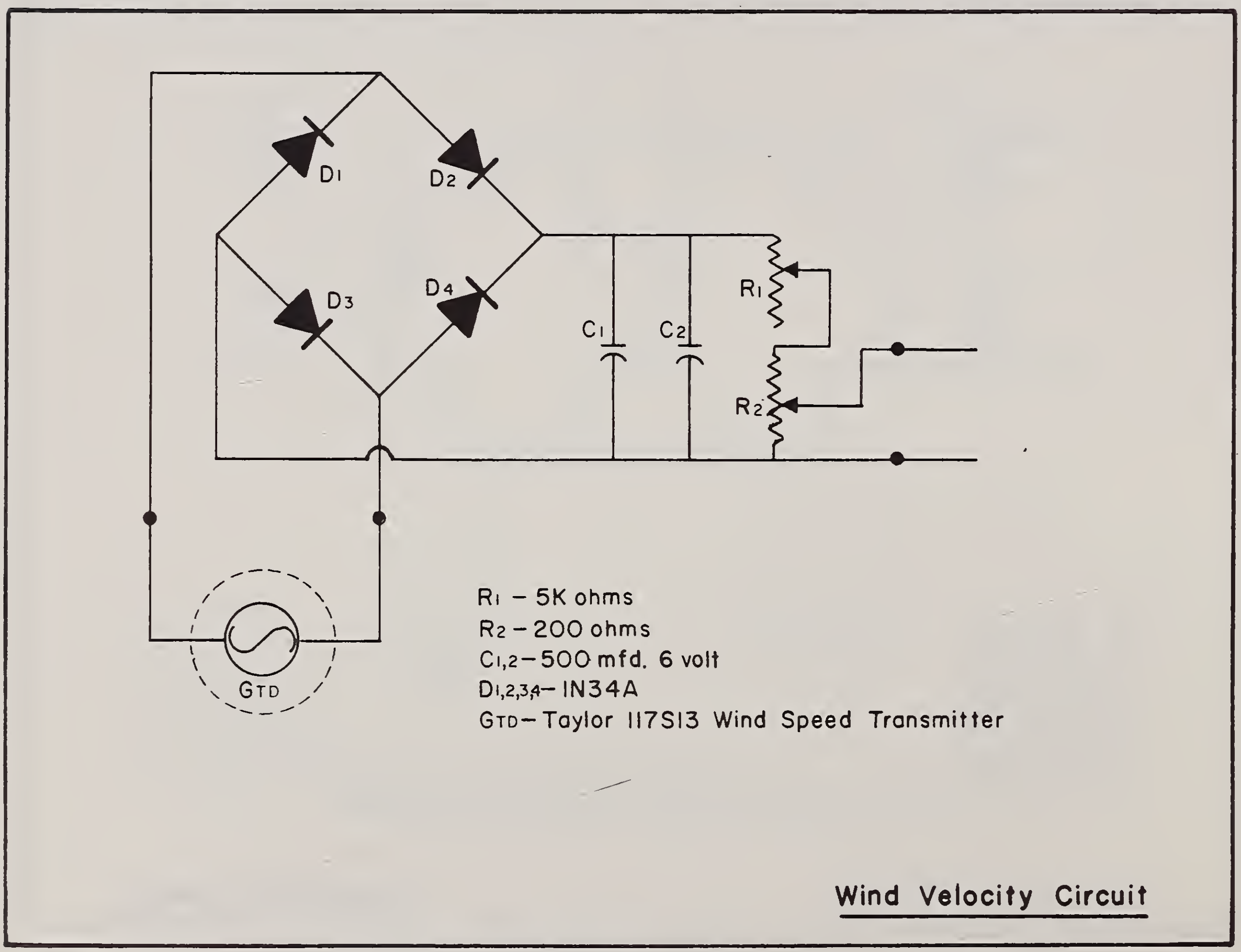


Figure 16.--Wind velocity printed circuit card and wiring diagram.

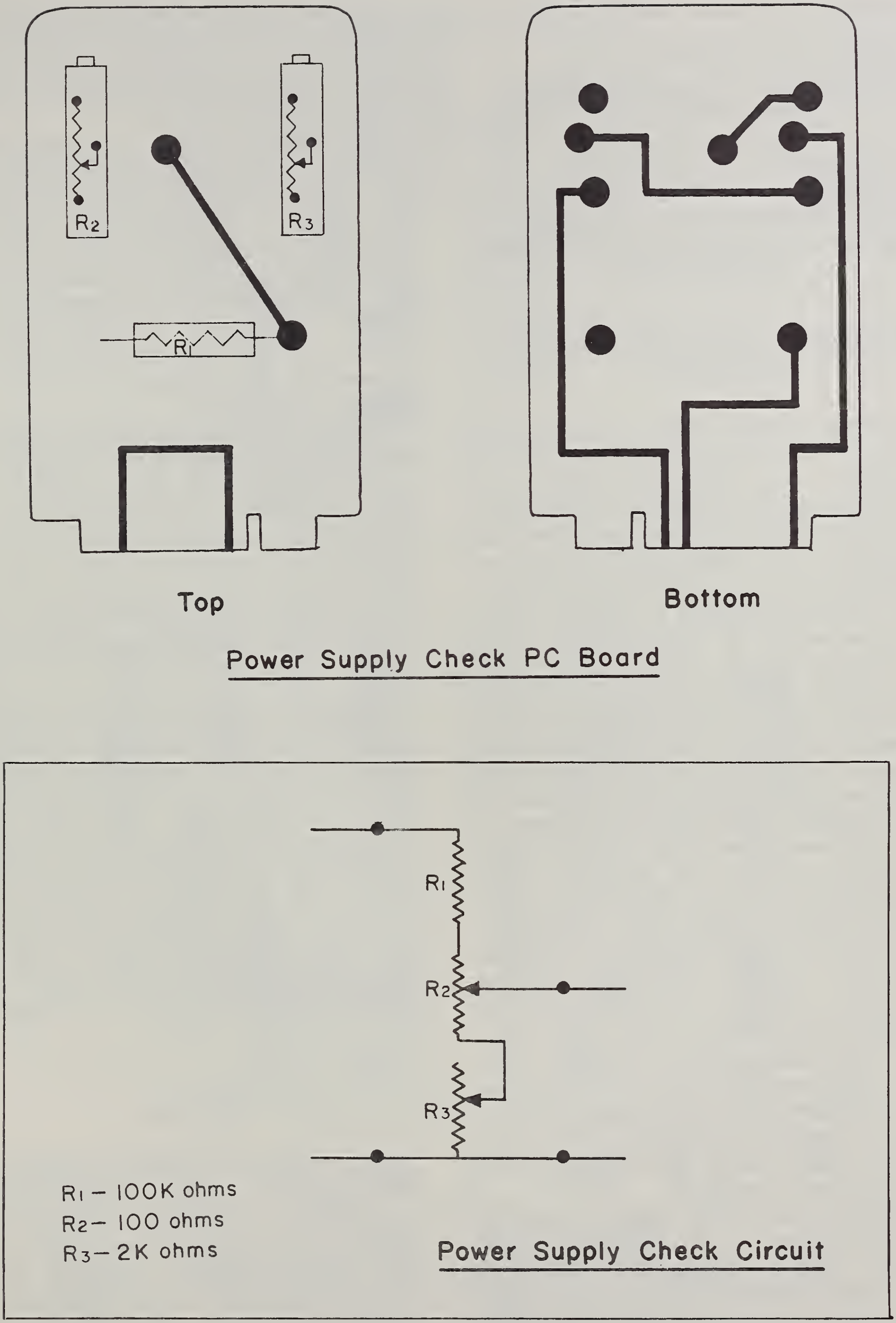


Figure 17.--Power supply check printed circuit card and wiring diagram.

Specifications for the counter include the following:

Operating voltage--115 v.a.c., 60 c.
Operating power--6 watts (approximate)
Count capability--600 (with 3600° rotation with potentiometer)
Counting speed--1 count per second
Reset time--10 minutes from full count
Mechanical reset accuracy--100 percent
Linearity--0.1 percent (limited by linearity of potentiometer)

Construction and Principles of Operation

The device, shown in figure 18, is mounted on a 3" x 3" x 3/16" angle iron frame approximately 4" in length. The shafts of the drive motor and the precision potentiometer are inserted in holes drilled through the legs of the angle iron. A double threaded worm and a single lobe cam are fastened to the motor shaft. The worm engages a 120-tooth worm gear attached to the potentiometer shaft. A 1/2-inch, 20- thread, hollow, stainless steel stud is silver soldered concentric to the face of the worm gear. The rivet head cam lobe is fastened to the face of the worm gear near the edge of the gear. A microswitch is mounted on a rocker arm parallel to the 1/2-inch, 20-thread, stainless stud and is positioned so that it will contact the rivet head cam lobe. A 1/2-inch, 20-thread nut is formed from 7/8-inch-diameter brass rod that has been filed flat on one side except for a 1/8" square ridge parallel to the threaded hole. The ridge on this nut acts as a pusher block to tilt the microswitch rocker-arm mount and operate the microswitch at zero count position. The same ridge, riding in a loose-fit slot on the rocker arm, prevents the nut from rotating with the stainless steel stud. A second microswitch is mounted on the inside face of one leg of the angle iron in such position that it engages the worm cam.

In operation the motor drives continuously in such direction as to accumulate count (fig. 19). "COUNT" begins when contact is made across terminals 1 and 3, thus feeding a 115 v.a.c. pulse to the motor clutch. This contact closure must have a duration of less than 1 second. The worm cam microswitch, normally open contact, maintains clutch engagement until the worm has made one complete revolution. The clutch then drops out and remains disengaged until additional "COUNT" pulses are entered.

Reset is obtained by contact closure across terminals 1 and 6, thus feeding a 115 v.a.c. "RESET" pulse to the double pole double-throw (d.p.d.t.) latching relay. This relay reverses the rotation of the drive motor and contacts the motor clutch through the worm gear cam microswitch with normally closed contact. The motor continues driving in "RESET" rotation until the worm gear cam microswitch breaks contact to the motor clutch.

Immediately after the worm gear cam microswitch breaks contact to the motor clutch, current flows through the microswitch normally open contact to the second coil of the latching relay and reverses the motor drive connection to "COUNT" rotation. Since the current from the worm gear cam microswitch to the second coil is handled through a set of the relay's own contacts, this circuit is broken as soon as the relay latches in the "COUNT" position.

Adjustment of the worm gear cam microswitch is not highly critical, as might be supposed. When the relay switches back to "COUNT" position the worm cam microswitch will re-engage the motor clutch, momentarily, to turn the worm in "COUNT" rotation until it reaches its "ZERO COUNT" position. The accuracy of mechanical reset is limited only by backlash in the gear train. Since this backlash is always taken up in the same direction of rotation, the accuracy of mechanical reset is essentially 100 percent.

Wiring

Relay, capacitor, resistors, and diodes are all mounted on a printed circuit board that is inserted in a printed circuit connector, fastened to the main frame angle iron. A four pin, chassis mounted, connector plug is mounted through one wall of the angle iron on the bottom edge of the assembly. This connector is used for power supply and pulse circuits.

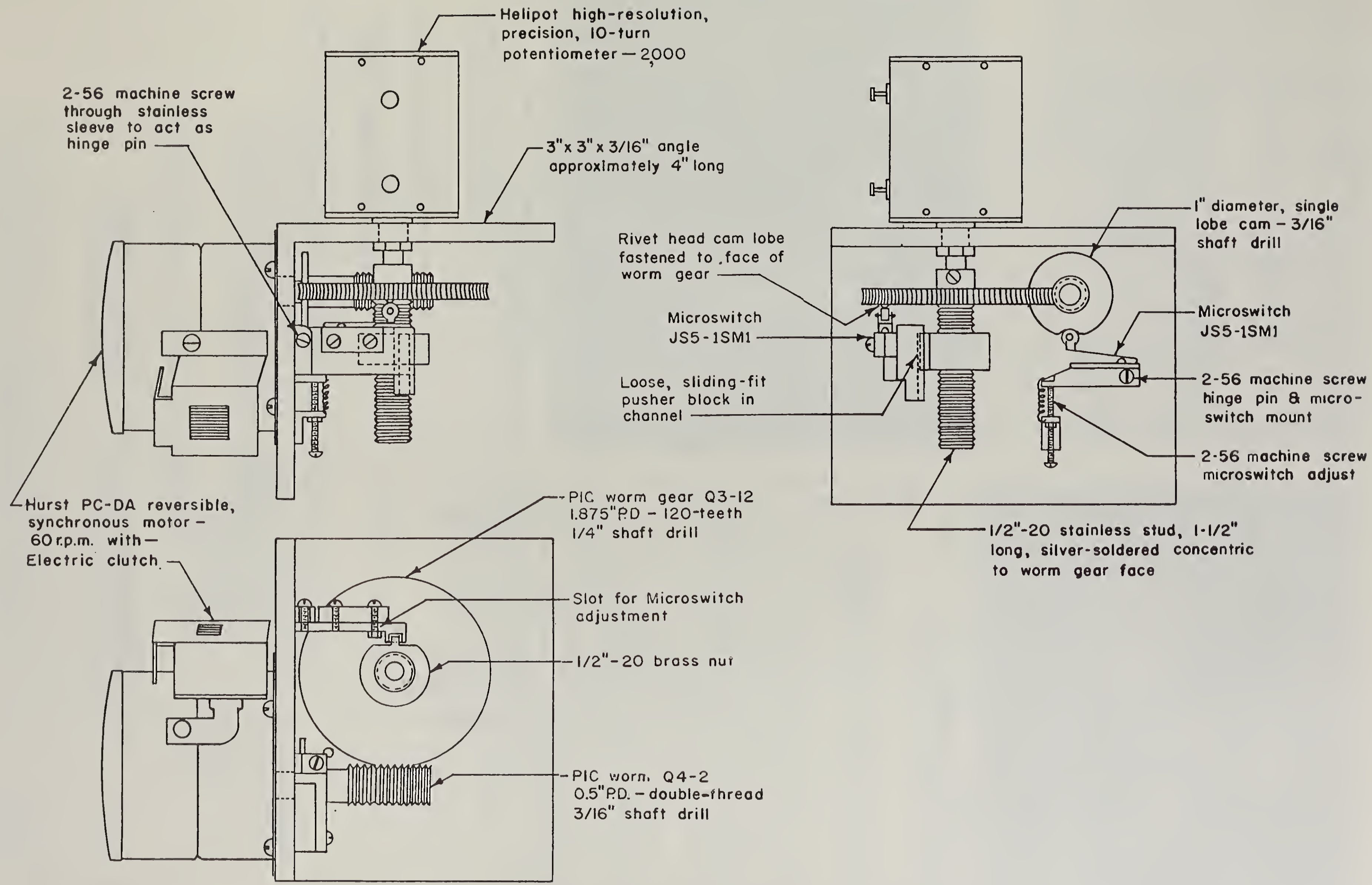
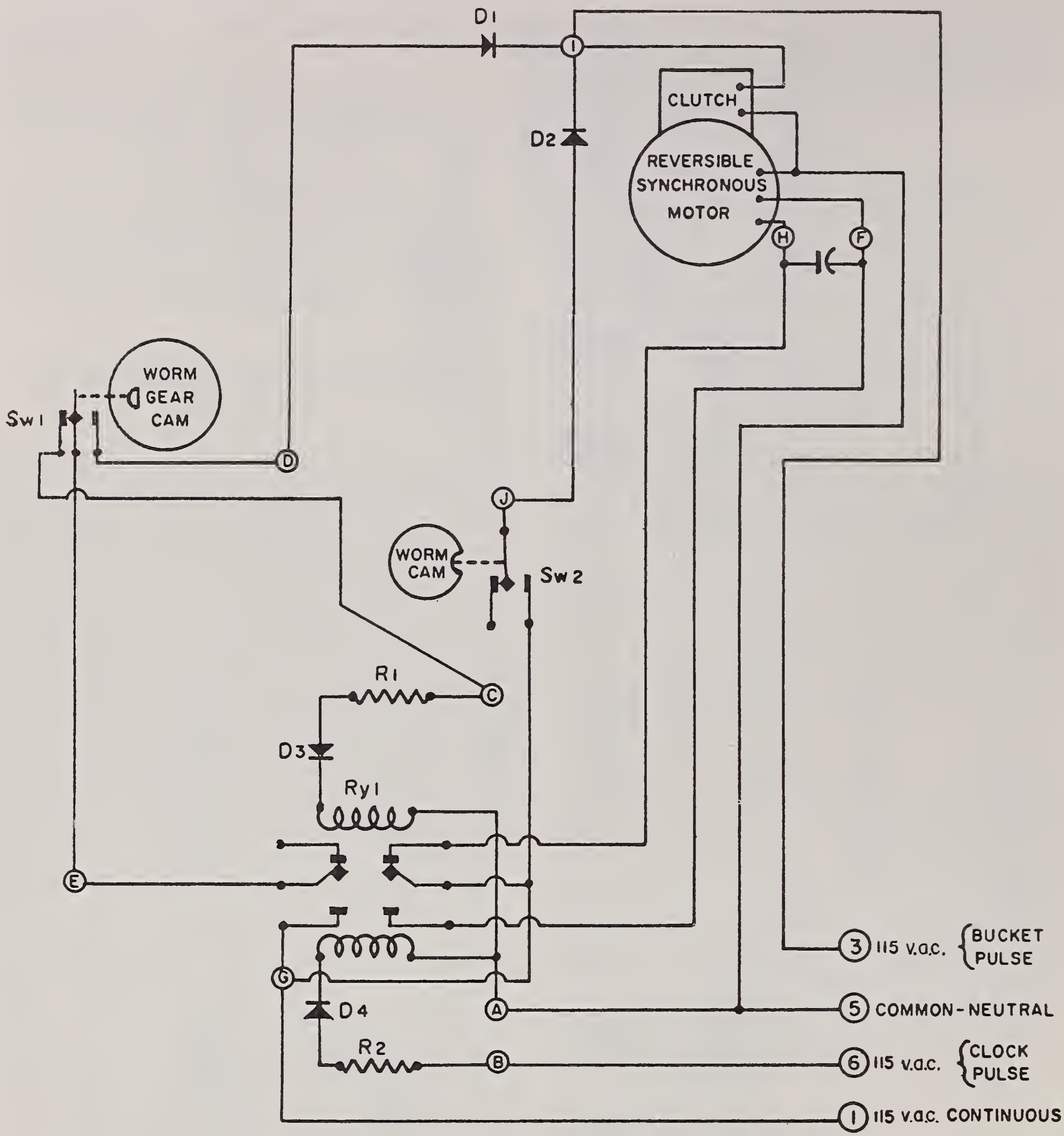


Figure 18.--Mechanical diagram of electromechanical counter.



NOTE: Motor·········Hurst PC-DA, 60 r.p.m.
Relay··········Potter & Brumfield SL11D-24 v.d.c.
D1-2-3-4·······Diodes 1N3639
R1-2··········2,400 ohms
Sw1-2·········Micro JS5-1SM1

Figure 19.--Electrical Diagram of electromechanical counter.

The only critical wiring is that used to connect the worm gear cam microswitch. Very flexible wire should be used at this location to prevent restriction of the rocker-arm motion.

The completed counter assembly with printed circuit board removed and inserted is illustrated in figures 20 and 21. The entire assembly is approximately 5" x 4" x 4".

All commercially manufactured parts used in construction of the assembly were procured for less than $60.

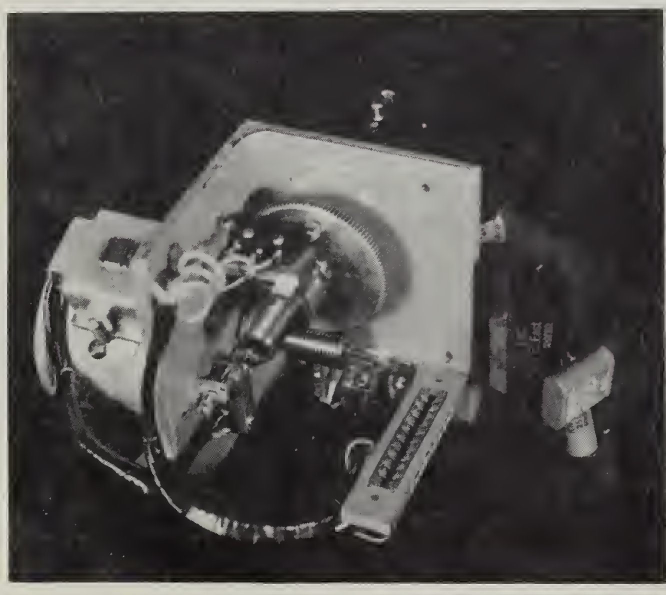


Figure 20.--View of electromechanical counter with accessory circuit board removed.

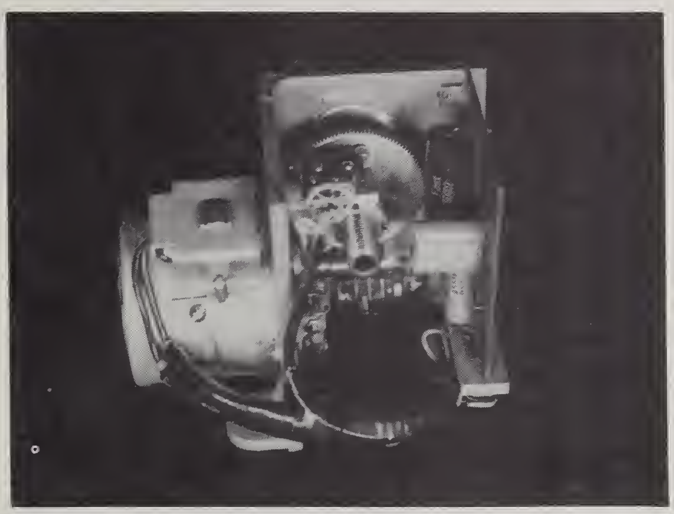


Figure 21.--View of electromechanical counter with accessory circuit board inserted.

COST OF COMPONENTS

Twenty-five purchase orders were written to secure all parts for the weather station and resulted in obtaining parts made by at least 75 manufacturers. Five of the purchase orders were directed to wholesalers for miscellaneous hardware and parts.

Actual costs shown in the following tabulation were taken directly from AD-107 "Report of Construction Of Property."[13] The total cost of the logger includes all printed circuit bridge networks, Dewcel power supply, precipitation electromechanical counter, and thermocouple reference junction.

[13] All prices refer to the year 1964.

Digital Data Logger:

(1) Non-Linear Systems RS3	Scanner-Tape Punch	
(1) Non-Linear Systems 144	Decade Preamplifier	..... $4,856.00
(1) Non-Linear Systems 4813	Digital Voltmeter	
(1) Chrono-log 2700-2	Digital Clock	591.00

(1) Technipower RM 5.25 containing:

(1) N-9.8-0.750AY	9.8 volt power supply	.... 224.97
(1) NR-28.0-0.750	28.0 volt power supply	

(1) Fenwal 53601-0 Proportioning Thermistor Controller...	107.30
(1) Par-Metal Deluxe Console Assembly (Cabinet)..............	253.14

Miscellaneous hardware, electronic components, switch gear, connectors, and art supplies:

Allied Electronics	$272.91
American Pamcor	29.88
C. P. Clare	25.40
Cannon Electric	12.36
Universal Relay	11.52
Signal Transformer	17.00
Dale Electronics	85.20
PIC Design	10.50
Alpha Wire	25.50
Prestype	12.00
Ack Radio	63.00
Herbach & Rademan	8.50
Allied Electronics	14.60
Bynum Paints	18.80
TOTAL	6,639.58

Transducers and Accessories:

Taylor Instrument:

(4) 117513 Wind Speed Transmitting Units (4) 110S50 Wind Direction Transmitting Units	$240.00

Belfort Instrument:

(1) 1050 Tilting bucket (1) 5610 Tilting bucket frame	90.00
(4) Foxboro 2711AG "Dewcel" (Dewpoint Transducers)	385.85
(4) Foxboro DB-IR-26W "Dynatherm" (Temperature Transducers)	128.00
Georgia Valve & Fitting $ 5.60 Coating Laboratories 10.00 — Miscellaneous hardware and paint	15.60
Total	859.45

Automatic Weather Station Total:

Data Logger	$6,639.58
Transducers	859.45
Total	7,499.03

COMMENTS ON OPERATION AND MAINTENANCE

The data logger was shock mounted on a pallet equipped with overhead hoist rings. The entire assembly was crated with plywood. In November 1964, the crate was carried by pickup truck 70 miles to Atlanta Muncipal Airport. From this point it was shipped airfreight to San Juan, Puerto Rico. The crate was then trucked to Maricao, Puerto Rico, by way of Mayaguez, a distance of about 100 miles. With the crate suspended by steel cable, a helicopter delivered the equipment to final site of installation.

The equipment was installed in a 6' x 8' steel toolhouse in January 1965. In April 1965 some recalibration of the transducer circuits was accomplished, and the wind direction transmitters were modified by addition of a second wiper arm. Although the equipment had been subjected to high moisture, it had apparently not deteriorated.

In February 1966 a Flexowriter was procured for printout of the punched paper tape. The Flexowriter was capable of reading 8-bit tape, whereas the logger punched 6-bit tape. To make the two components compatible in the quickest and least expensive manner it was decided to change the logger tape coding.

A new code matrix board was prepared and installed in the logger on March 1, 1966. All circuits were recalibrated, and operation of the logger was thoroughly checked out. Only one failure showed up. The normally closed contact of the transfer relay, which inserts the function identification character "m", was not making electrical contact. Operation was restored by cleaning and lubricating all contacts with corrosion-inhibiting contact cleaner. The logger had not been in general use for several months and extremely high humidities were believed to have been responsible for the failure.

Function controls on the logger-tape punch and digital voltmeter permit operation in any one of four methods as follows:

1. Equipment may be set to produce a complete punch-out of all channels once each 5, 10, 20, 30, or 60 minutes.
2. Equipment may be set to produce punch-out of individual channel of information on manual demand.
3. Equipment may be set to produce continuous complete punch-out of all channels as fast as the digital voltmeter will balance.
4. Equipment may be set to produce readout only of any channel.

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